The asymmetric effects of exploitation and exploration on radical and incremental innovation performance : an uneven affair

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Keywords: Exploitation, Exploration, Ambidexterity, Incremental innovation performance, Radical innovation performance

1. Introduction

Since March's (1991) seminal work on exploitation and exploration in organizational learning, researchers have been concerned with the blend of exploitation and exploration in order to enhance performance (Benner & Tushman, 2003; Gupta, Smith, & Shalley, 2006; Luger, Raisch, & Schimmer, 2018; O'Reilly III & Tushman, 2008; Papachroni, Heracleous, & Paroutis, 2015; Raisch & Birkinshaw, 2008; Walrave, Romme, van Oorschot, & Langerak, 2017). In this vein, scholars have argued that the interaction of the two learning processes (i.e., exploitation and exploration) provides a source of competitive advantage beyond that provided by each individually (Andriopoulos & Lewis, 2009; Colbert, 2004; Gibson & Birkinshaw, 2004; Petersen, Boer, & Gertsen, 2004). Further, scholars have emphasized the importance of better understanding this interaction and its effects, particularly in innovation contexts (Lee, Woo, & Joshi, 2017; Raisch & Birkinshaw, 2008; Sarkees & Hulland, 2009). Accordingly, extant research has studied and found interaction effects of exploitation and exploration on innovation performance overall (Katila & Ahuja, 2002; Lee, et al., 2017; Nerkar, 2003; Russo & Vurro, 2010).

The literature on innovation in organizational contexts has moved beyond a unitary concept of innovation and has developed the widely acknowledged dichotomy of radical and incremental innovation (Dewar & Dutton, 1986; Ettlie, Bridges, & O'Keefe, 1984). Moreover, the literature has emphasized that firms need to attain both types of innovation to sustain competitive advantage (Tushman, 1997). Consequently, extant research has examined the independent direct effects of exploitation and exploration and has uncovered that incremental innovation performance is driven by exploitation and that radical innovation performance is driven by exploration (Arnold, Fang, & Palmatier, 2011; Atuahene-Gima, 2005). However, we know little about the mutual effects of exploitation and exploration on either *incremental* or *radical* innovation performance, despite the argument of earlier research that the interaction of the two learning processes may provide benefits beyond those provided by each individually (Gibson & Birkinshaw, 2004). Overall, our theoretical and empirical understanding of the respective interaction effects is underdeveloped. We address this gap and examine the following research question: What are the interaction effects of exploitation and exploration on incremental and radical innovation respectively? We answer this research question by examining linear and non-linear effects and, thus, contribute to a better theoretical and empirical understanding of what blend of exploitation and exploration is most beneficial. The insights of this research are relevant as exploitation and exploration compete for an organization's resources, which are rarely abundant (Greve, 2007; Levinthal & March, 1993). Hence, important for the effective but also efficient conversion of resources to successful performance is the purposive division of the available resources to exploitation and exploration (Garcia, Calantone, & Levine, 2003). The results of our study provide the foundations for such purposive division, which is a fundamental managerial task.

For this study, we collected data from 171 manufacturing firms in Switzerland. The results of our analysis reveal that incremental innovation performance benefits from exploitation but is even higher when exploitation interacts with an intermediate level of exploration. Radical innovation performance, on the other hand, is solely driven by exploration. Our study offers novel insights and makes important contributions to the literature: First, we contribute to the innovation management literature by disentangling the interaction effects that have been studied related to innovation performance overall by explaining the interaction effects of exploitation and exploration on radical and incremental innovation performance, respectively. Second, we contribute to the theoretical foundations of organizational learning. Our results lend theoretical and empirical support to an asymmetrical relationship of exploitation and exploration. The literature has unitarily agreed with March (1991) who proposes to maintain an appropriate balance of exploitation and exploration for innovation performance and has provided theoretical and empirical support for the notion of balance as a symmetrical presence and magnitude of exploitation and exploration (He & Wong, 2004; Katila & Ahuja, 2002). By hypothesizing and testing for non-linear effects, we find that the relationship between exploration and exploitation, on the one hand, and the two innovation performance types (radical and incremental), on the other hand, is asymmetric and more complex than originally thought. The results of our study can aid managers in designing their organizations for continuous innovation performance and competitive advantage.

2. Theory

Product innovations are crucial for firms' long term competitiveness and survival as they differ in their respective novelty and are commonly distinguished into radical and incremental innovation (Dewar & Dutton, 1986; Dosi, 1982). *Radical innovations* involve fundamental changes in a firm's technology. Radically new products typically address the needs of emerging customers, are new to the firm and/or the industry, exceed customer expectations, and offer the customer substantial new benefits. Examples are the Tesla roadster, the first electric sports car, and the Transrapid, a train using magnetic levitation. In contrast, *incremental innovation* refers to comparatively minor adaptations of existing products, i.e., with only small changes in the technology, design and/or fresh look, product relaunches, and line extensions that are new for the company but not new for the market {Chandy, 1998 #97}. Oreo Thins, a skinnier version of the classic Oreo cookie, and iPad mini, a smaller format of the Apple iPad, are examples of incremental innovations.

The development of product innovations can be nurtured by two types of learning processes: exploitation and exploration (Atuahene-Gima & Murray, 2007; Cohen & Levinthal, 1989; Fiol & Lyles, 1985). *Exploitation* comprises activities that utilize, i.e., refine and extend existing knowledge, competencies, technologies, and paradigms. It is associated with mechanistic structures, tightly coupled systems, path dependence, routinization, control and bureaucracy, and stable markets and technologies (He & Wong, 2004; Raisch & Birkinshaw, 2008). In contrast, *exploration* refers to learning and searching for and acquiring new knowledge by distant search activities, i.e., searching in knowledge trajectories that are far from the firm's current knowledge domain. It is associated with organic structures, loosely coupled systems, and improvisation (Benner & Tushman, 2003; Cyert & March, 1963; Gupta, et al., 2006; March, 1991).

2.1. The effects of exploitation and exploration on incremental and radical innovation performance

Studies on firms' innovation performance recognize exploitation and exploration as essential antecedents (Atuahene-Gima, 2005; Greve, 2007; Hortinha, Lages, & Filipe Lages, 2011). Having thoroughly reviewed the literature, we identified 13 studies that connect ambidexterity and innovation performance. Further, our analysis revealed that these studies form two streams of research (see Figure 1). The first research stream perceives direct, independent, and linear effects of exploitation and exploration on two different innovation types, namely incremental and radical innovation performance (e.g., Atuahene-Gima, 2005; Yalcinkaya, Calantone, & Griffith, 2007). The studies of this stream consistently find exploitation beneficial for incremental and exploration beneficial for radical innovation performance (e.g., Arnold, et al., 2011; Yalcinkaya, et al., 2007). In addition, the majority of studies finds that exploration is also beneficial for incremental innovation performance but exploitation is rather detrimental to radical innovation performance (e.g., Hernandez-Espallardo, Molina-Castillo, & Rodriguez-Orejuela, 2012; Yalcinkaya, et al., 2007) (See Table 1). The second research stream studies the effects of exploitation and exploration on innovation performance overall and does not differentiate between incremental and radical innovation (Atuahene-Gima & Murray, 2007; He & Wong, 2004; Katila & Ahuja, 2002; Lee, et al., 2017; Nerkar, 2003; Russo & Vurro, 2010). However, this second research stream moves beyond the study of the direct, independent, and linear effects of exploitation and exploration and hypothesizes and tests curvilinear effects and interaction effects (see Table 2).

Insert Figure 1, Table 1, and Table 2 about here

In our study, we integrate the two streams and study the interaction effects of exploitation and exploration on both incremental and radical innovation performance and, thus, address an important gap in the literature. Building on the contributions of scholars who have studied the independent effects of exploitation and exploration on incremental and on radical innovation performance (see Table 1), we contribute to disentangling the interaction effects that have been studied related to innovation performance overall (see Table 2) by considering both incremental and radical innovation performance as dependent variables. The literature offers one study that contributes to the integration of the two research streams (Atuahene-Gima, 2005). Concerning incremental innovation performance, Atuahene-Gima (2005), the author of this study, hypothesizes a non-directional interaction effect of exploitation and exploration, but finds no significance. Positing a non-directional interaction effect on radical innovation performance, he finds a negative effect. The results of a further and post-hoc analysis of his data lend support to a conclusion that a high exploration – low exploitation blend is most beneficial for radical innovation performance. We build and extend Atuahene-Gima's work by theoretically developing directed hypotheses. Moreover, we not only test linear but also propose and test curvilinear effects. To study these effects is of relevance as exploitation and exploration compete for limited resources and the allocation of these resources is a fundamental managerial task in enhancing product innovation outcomes. Particularly insights into the interaction effects of exploitation and exploration that provide beneficial performance effects beyond those provided by each individually provide a foundation to use the available resources more efficiently.

Overall, we supplement the extant literature theoretically and empirically. As we focus on how firms use existent knowledge and generate new knowledge about technologies and/or customers for innovative new products, we base and develop our arguments on the theoretical foundations of organizational knowledge and learning.

2.2. Exploitation, exploration, and ambidexterity

In our study, we follow the predominant view of the literature on organizational learning which perceives ambidexterity as firms' capabilities to balance, or simultaneously pursue, exploration and exploitation (e.g., Benner & Tushman, 2003; Cao, Gedajlovic, & Zhang, 2009; Raisch & Birkinshaw, 2008) and which considers ambidexterity to be conceptually different from alternative solutions, such as cycling or temporal separation, which considers that exploration and exploitation coexist in the same organizational unit but at different points in time (Lavie, Stettner, & Tushman, 2010; Luger, et al., 2018). While there is broad consensus in the literature that ambidexterity is based on the two subconcepts of exploration and exploitation (He & Wong, 2004; Lubatkin, Simsek, Ling, & Veiga, 2006; Tushman & O'Reilly III, 1996), the literature conceptualizes the relationship between exploitation and exploration in different ways (Cao, et al., 2009; Gupta, et al., 2006; He & Wong, 2004). One strand of the literature perceives exploration and exploitation as two ends of a continuum (Heyden, Oehmichen, Nichting, & Volberda, 2015; Lavie & Rosenkopf, 2006). The other strand conceptualizes exploitation and exploration as orthogonal variables (Baum, Li, & Usher, 2000; Gupta, et al., 2006; Katila & Ahuja, 2002; Nerkar, 2003). As we understand exploitation and exploration as two kinds of learning activity, both valuable and realizable, this study is based on the orthogonal conceptualization of exploitation and exploration, which enables us to examine the innovation performance implications of the interrelationship between the two (Wang & Li, 2008).

Further, ambidexterity researchers have typically focused either on the organizational level (e.g., He & Wong, 2004; O'Reilly III & Tushman, 2013) or on the individual level. The latter view ambidexterity in paradoxical terms and emphasize not only integration but also the synthesis of exploitation and exploration (e.g., Papachroni, et al., 2015; Stokes, et al., 2015). This study, however, is situated at the organizational level. It seeks to shed light on how organizations best blend the two disparate learning processes of exploitation and exploration to obtain best performance results for incremental and radical innovation respectively. Finally, we take a static stance as opposed to a dynamic perspective on balancing exploitation and exploration (Luger, et al., 2018; Stokes, et al., 2015; Walrave, et al., 2017). While the latter studies the adaptation of the exploitation-exploration-blend over time, we take a first step by addressing the gap of understanding the appropriate balance of exploration and exploitation for radical and incremental innovation performance at a given instant.

2.3. Incremental and radical innovation performance

In this research, innovation performance refers to innovation outcome which "involves innovation frequency or the number of new products developed and marketed" (Parthasarthy & Hammond, 2002, p. 75). Thus, we focus on product innovation. Many studies assessing the mutual effects of exploitation and exploration examine product innovation performance in general (Katila & Ahuja, 2002; Nerkar, 2003), yet studies point to clear differences between radical and incremental innovation performance (Atuahene-Gima, 2005; Corso & Pellegrini, 2007). As a result, we differentiate the dependent variable of product innovation into two distinct levels of product innovation newness explicitly, i.e., we consider incremental and radical product innovation (Dewar & Dutton, 1986; Ettlie, et al., 1984; Tushman & Anderson, 1986). To do so, we consider whether or not a product innovation incorporates a technology that is a clear, risky departure from existing practice (Hage, 1980). Moreover, we consider radical and incremental innovation *performance* in our study as opposed to radical and incremental innovation per se. Radical innovation, for example, can occur as a technological breakthrough in a lab where it remains non-consequential for various reasons such as being too advanced an innovation. Alternatively, such a radical innovation can be successful in the market, generate sales and, thus, constitute radical innovation performance.

Further, we conceptualize radical and incremental innovation as two distinct constructs rather than two extremes of a single continuum. The literature has conceptualized radical and incremental innovation in two ways. On the one hand, it has treated radical and incremental innovation as two ends of a continuum, where the level of novelty is decisive whether an innovation is closer to incremental (low level of novelty) or closer to radical (high level of novelty). On the other hand, the literature understands incremental and radical innovation performance as two distinct constructs of innovation performance, both of which are realizable. It is the second conceptualization that has been adopted more broadly and that we follow in our study (Dewar & Dutton, 1986; Salavou, 2004). Thus, we are able to analyze the joint effects of exploitation and exploration on radical innovation performance and on incremental performance separately.

In addition, some scholars describe incremental innovations as exploitative, and radical innovations as explorative (Benner & Tushman, 2003; Danneels, 2002; Holmqvist, 2004; Lin, McDonough, Lin, & Lin, 2013; Mueller, Rosenbusch, & Bausch, 2013; Smith & Tushman, 2005).

Contrary to this notion, we conceptualize exploitation and exploration as a firm's learning processes which are distinct from a firm's product innovation output (Levinthal & March, 1993; March, 1991).

3. Hypotheses

Firms engaging in exploitation and, thus, building on existing sets of knowledge elements will likely attain incremental innovation performance. Further, by replicating past actions, firms accumulate knowledge, become more competent, and move along the learning curve (Gupta, et al., 2006). As a result, the products innovated will, for example, be more durable or feature incrementally new functionalities. When firms blend exploitation with exploration, this is likely to be even more beneficial to incremental innovation performance (Andriopoulos & Lewis, 2009; Colbert, 2004; Petersen, et al., 2004). Given a set of knowledge components, the number of possible re-combinations is limited. Potential future combinations become exhausted, partly owing to the diminished ability of developers to conceive of new applications (Wu & Shanley, 2009). Adding distant knowledge elements to the existent set of knowledge often provides new stimuli for combining knowledge elements in a novel way (Brockman & Morgan, 2003; Dewar & Dutton, 1986; March, 1991). This helps firms to both innovate and avoid core rigidity (Leonard-Barton, 1992; Wu & Shanley, 2009). For example, firms supplying modern cars' steering columns today supplement their products with electronic steering support. The electronic knowledge needed to do this is radically different from the materials and mechanical expertise that firms traditionally exploited to provide these innovative vehicle components. Now, the driver needs to provide only a modest steering effort regardless of conditions, because the electronics add controlled energy to the steering mechanism. However, the overall product was incrementally new. (It would be radically new if it enabled cars to be steered by wire and a joystick.) In conclusion, introducing new technology into existing products may lead to the development of new functionalities or to improved performance. Firms that keep themselves up-to-date with the latest developments in their domains can take advantage of the continuing relevance of existent technological capabilities by combining them, thus increasing the likelihood of developing innovative products in an incremental manner (Wu & Shanley, 2009). Overall, we argue – in line with the organizational learning literature – that increased knowledge scope through exploration is likely to further enhance incremental innovation performance (Kogut & Zander, 1992; Leonard-Barton, 1992; Wu & Shanley, 2009).

However, too much exploration can hamper the benefits of exploitation on incremental innovation performance. The coordination and integration of distant knowledge that is acquired through exploration is costly. Beyond a certain point, these costs outweigh the benefits of exploration. For example, when a firm generates so many ideas distant from the knowledge inherent in its existing product portfolio or when it suddenly acquires a large amount of technological knowledge, innovation performance will be hampered for two reasons. First, firms may fail to effectively assimilate these (Levinthal & March, 1993; Li, Chu, & Lin, 2010). Search and integration require resources, time, and fitting support mechanisms such as decision making in the course of innovation activities. At the same time, less data is available to make those decisions that might have costly effects (Wu & Shanley, 2009). Second, the new knowledge introduced to the firm by exploration may disrupt organizational routines and may reduce overall productivity. Eventually, dynamically increasing integration costs might dampen the benefits of exploring new knowledge, thereby hurting exploitation's positive effect on incremental innovation performance (Ahuja & Katila, 2001; Katila & Ahuja, 2002). Overall, we propose that:

H_1: Exploration has a curvilinear (inverse U-shaped) moderator effect on exploitation's effect on incremental innovation performance.

When engaging in explorative learning activities, a firm gains significant amounts of new and distant knowledge, which may lead to radical innovation performance (Grant, 1996). Moreover, the organizational learning literature indicates that supplementing explorative with exploitative learning may be even more beneficial because exploitation increases a firm's capacity to explore and identify and assimilate new knowledge elements. In particular, exploitation entails routinization and the repeated usage of a given set of knowledge, which leads to an increase in a firm's absorptive capacity to identify and assimilate valuable new knowledge elements (Cohen & Levinthal, 1990; Corso & Pellegrini, 2007; Fiol & Lyles, 1985). I.e., exploitation can assist organizations in evaluating distant knowledge and, thus, in reducing the likelihood of costly errors when roaming in new fields (Brockman & Morgan, 2003; Levinthal & March, 1993; Moorman & Miner, 1997; Zahra & George, 2002).

Further, exploitation, which revolves around the firm's current knowledge, may serve as leverage point to assimilating and utilizing new knowledge (Levinthal & March, 1993; Zahra & George, 2002). When Apple Inc. introduced mobile applications (i.e., Apps), this was radically new. While exploring this market and the corresponding technology, the firm exploited its existing customer base, market knowledge, and technological knowledge of smart phones (i.e., the iPhone). These are needed to use the Apps (Reinmoeller, 2008). Overall, Apple Inc. not only explored new knowledge areas, but also linked these to its existent core knowledge area (Nonaka, Kodama, Hirose, & Kohlbacher, 2014). Hence, linking explorative learning with existing knowledge and experience can help a firm to integrate and transform distant knowledge effectively and, thus, attain products that are radically new to the market.

However, increasing levels of exploitation that accompany exploration can be detrimental. Exploitation can begin to drive out exploration after a certain point (Atuahene-Gima & Murray, 2007; Nerkar, 2003). Organizations learn from experience how to divide resources between exploitation and exploration. Exploitation generates returns that are more certain and temporally more proximate than is the case with exploration. This proximity of returns leads organizations to increasingly assign resources to exploitation and to perceive exploration as an inferior activity (Greve, 2007; Levinthal & March, 1993; March, 1991). As a result, the much-needed variety generated by exploration becomes repressed which is detrimental to radical innovation performance (Fang, Lee, & Schilling, 2010). Hence, organizational learning theory advocates that beyond a certain point, exploitation may hinder the positive effect of exploration on radical innovations (Christensen & Bower, 1996; Danneels, 2002).

Overall, we argue that an intermediate exploitation level will provide the desired channeling of explorative activities for radical innovation and the heterogeneous ideas it creates as it helps integrate and realize these ideas. Thus, we posit that:

H_2: Exploitation has a curvilinear (inverse U-shaped) moderator effect on exploration's effect on radical innovation performance.

Insert Figure 2 about here

Figure 2 provides an overview of our hypotheses.

4. Methods

4.1. Data and sample

To test our hypotheses, we surveyed firms in Switzerland which is frequently rated as being the most innovative country worldwide (Kelley, Singer, & Herrington, 2016). Our research is concerned with innovation performance. Consequently, a country with many innovative firms is a favorable setting that allows us to observe firms that are innovative to various degrees. We collected our data by means of two waves of personalized mailings to CEOs and senior executives in Swiss companies. The names of the executives were obtained from a commercial sampling list including 60% addresses of CEO and 40% addresses of senior executives. We conducted the survey in German but offered an English version of the questionnaire if requested. The 12-page questionnaire covered issues relating to business, innovation and innovation strategy, innovation performance, resources and capabilities, and environmental aspects. We sent out 2490 questionnaires and obtained 379 usable questionnaires. Owing to the length of the questionnaire and the seniority of the managers targeted, the effective response rate of 15% is satisfactory (Diamantopoulos & Schlegelmilch, 1996). As our study focuses on product innovations, we excluded all questionnaires from service industries. The remaining sample consists of 171 manufacturers from the following industries: consumer durables (25%), fast-moving consumer goods (25%), and material and components (27%) as well as capital industrial equipment (23%). 51% of the companies in the sample had between 20 and 99 employees (small firms), 36% between 100 and 499 employees (medium-sized firms), and 13% had 500 or more employees (large companies). The extrapolation procedure described by Armstrong and Overton (1977) was used to test for non-response bias. T-tests show no significant differences across the model variables between those responding before or after the second mailing.

4.2. Measures

We sourced measures for radical and incremental innovation performance, as well as exploration and exploitation constructs, from existing measurement batteries. All the measures were professionally translated, with a back-translation to ensure conceptual equivalence (Hoskisson, Eden, Lau, & Wright, 2000). We also conducted pre-study interviews with 15 practitioners of different industries to check comprehensiveness and to ensure and to ensure the applicability of the items across different industries and that the operationalizations measure the constructs they are supposed to measure. A list of the measurement items is provided in Table 3.

Incremental and *radical innovation performance* as well as *exploitation* and *exploration* were measured using the scales adopted with reflective items from Atuahene-Gima (2005).

Control variables. We controlled for firm size, because some scholars suggest that larger firms might devote more resources to innovate (e.g. Barney, 1991). However, others suggest that large firms are less innovative than small firms because they may lack flexibility due to more bureaucratic inertia (e.g. Baldridge & Burnham, 1975). In the analysis, we classified the sample into small (20-99 employees), medium-sized (100-499 employees), and large companies (500 or more employees), and included firm size as dummy variables in the regression analyses. Dummy variables were also included to control for unobserved industry effects. Furthermore, we controlled for demand complexity and technological uncertainty, as well as for competitiveness, measured by means of one item each. These company characteristics and environmental aspects have a recognized effect on innovation performance (Henard & Szymanski, 2001). We also controlled for product development alliances, since they might affect innovation (de Man & Duysters, 2005).

5. Analysis and Results

5.1. Measurement assessment

For measurement validation, we followed the procedures proposed by Anderson and Gerbing (1988) and Bagozzi and Yi (1988). First, we ran exploratory factor analyses. The constructs were purified by deleting items that did not load in excess of .45. As shown in Table 3, the constructs' alpha reliabilities exceed the value of .50, regarded as minimally acceptable (Nunnally, 1967). Second, the measures were subjected to confirmatory factor analyses (CFA). All factor loadings were statistically significant ($p<.001$). The composite reliability coefficients of each construct scale ranged from .70 to .81, except for the control variable process efficiency with a value of .53. Thus, the findings demonstrate the measurement scales' convergent validity. Finally, we analyzed the discriminant validity. Table 3 shows the inter-correlations among the study's variables. The square roots of the average variance extracted values ranged from .53 to .72. In all cases, these values were greater than the intercorrelations (Hulland, 1999). The results provide good evidence of discriminant validity.

Insert Table 3 and Table 4 about here

As all constructs were collected from the same respondent in the same survey, Harman's one-factor test was used to address the common method variance issue (Podsakoff & Organ, 1986). We extracted nine factors with eigenvalues greater than one, accounting for 63% of the variance. The first factor did not account for the majority of the variance (only 12%), and there was no general factor in the unrotated factor structure. Thus, common method bias is unlikely to be a serious problem in the sample.

5.2. Test of hypotheses

We tested the hypotheses with two six-step hierarchical moderated regression analyses. We mean-centered the independent and control variables to overcome potential problems due to multicollinearity (Aiken & West, 1991). None of the assumptions for OLS estimation were violated. In our study, the variance inflation factor (VIF) of the variables was below 2.5, much smaller than the maximum threshold of 10, indicating that the coefficients are relatively free of multicollinearity. The residuals were normally distributed, with no serious outliers. The Durbin-

Watson statistics were close to 2.00, suggesting no first-order autocorrelation in the error terms. The results of the White test confirmed the homoscedastic characteristic of the models.

In model 1, we included the control variables to avoid spurious or masked effects. In models 2 and 3, we entered the main effects of exploitation (exploration) with regards to incremental (radical) innovation performance. In model 4, we included the squared effect of exploration (exploitation) with regards to incremental (radical) innovation performance. In model 5, we entered the linear by linear interaction of exploration and exploitation. Finally, in model 6, we included the quadratic by linear interaction of exploration (exploitation) and exploitation (exploration) with regards to incremental (radical) innovation performance.

Insert Table 5 and Table 6 about here

We interpreted the findings using Aiken and West's (1991) recommended step-down approach to assess the presence of interaction prior to testing the main effects. This approach assures that lower-order effects are interpreted properly as conditional or average effects. The step-down procedure results are displayed in Table 5 and Table 6. Starting with the highest-order term in the regression equation with regard to incremental (radical) innovation performance, Table 5 shows that the inclusion of the quadratic by linear interaction of exploration and exploitation significantly improves the model fit ($\Delta F = 4.16$, $p < .05$). Hence, we base our discussion of the results with regard to incremental innovation performance on the full model, i.e., model 6. In support of H_1, there is evidence of an inverse U-shaped effect of the interaction between exploration and exploitation on incremental innovation performance. The coefficient for the quadratic by linear interaction term (β = -.20) is significant and negative. As exploration is directly related to incremental innovation performance, it is a quasi-moderator of the relationship between exploitation and incremental innovation performance.

To test hypothesis 2, we also began with the full model, model 6 (see Table 6). Adding the linear by quadratic interaction of exploitation and exploration does not cause a significant increase in the explanatory power (ΔF = .00, n.s.). Thus, H_2 is not supported. Dropping this linear by quadratic interaction term from the equation next, model 5 shows that the linear interaction term of exploration and exploitation also makes no significant change in the model's explanatory power (ΔF = 1.40, n.s.). Model 4 shows the quadratic effect of exploitation is also not related to radical innovation performance (ΔF = .68, n.s.). Model 3 exhibits the results of the regression analysis of the main effects. There is evidence that exploration (β = .41) is positively associated with radical innovation performance, whereas exploitation is not significantly related. For an overview of the results, see Figure 3.

Insert Figure 3 about here

To gain further insights into exploration's inverse U-shaped moderator effect on exploitation's effect on incremental innovation performance, the moderator exploration was split into a high group (two standard deviations above the mean), a moderate group (at the mean), and a low group (two standard deviations below the mean). First, we conducted Chow tests in order to reveal potential differences of the strength of exploitation and incremental innovation's relationship between the subgroups (Prescott, 1986). The Chow test is not significant with regard to the comparison of the moderate and the high group (F = -2.87, n.s.), whereas differences between the low and the moderate group (F = 13.98 $p < .001$) and between the low and the high group (F = 12.09, $p < .001$) are significant. Thus, the tests indicate that exploration has an impact on the strength of the relationship between exploitation and incremental innovation performance. Apparently, exploitation has a much stronger impact when it is combined with a medium level of exploration than with a low or high level of exploration. No differences between high and low levels of exploration can be found. Secondly, we followed the procedures recommended by Aiken and West (1991). We plotted the interactions and conducted simple slope tests, using the unstandardized coefficients. Figure 4 shows that exploitation and incremental innovation performance (simple slope: β = .33, $p < .05$) have a positive relationship if the exploration is moderate, but no relationship if the exploration is high (simple slope: β = -.15, n.s.) or low (simple slope: β = -.01, n.s.). Figure 5 visualizes the inverse U-shaped moderator effect of exploration on the relationship between exploitation and incremental innovation.

Insert Figure 4 and Figure 5 about here

With regard to exploitation's inverse U-shaped moderator effect on the relationship between exploration and radical innovation performance, the results of the regression analysis do not indicate any moderator effect. Although the interaction of exploration and exploitation is not significant, exploitation might act as a "homologizer" and influence the strength of the relationship between exploration and radical innovation performance across homogeneous subgroups (Prescott, 1986). Therefore, we developed three subgroups based on exploitation (two standard deviations below/above the mean) and conducted Chow tests to test differences in the subgroups. The results of the Chow tests (F= 1.29, n.s., F = 0.91, n.s., F = 2.03, n.s.) do not show significant differences across the subgroups. Thus, exploitation is not a moderator of the relationship between exploration and radical innovation performance.

We tested the robustness of the results using a subset of the sample in which we removed large firms. It might be more difficult for respondents from large firms than for those from medium-sized and small firms to provide a good assessment of the extent to which their firm is involved in exploration and exploitation learning activities. However, the results of the replicated analyses using the reduced sample exhibited the same pattern as the results based on the full sample.

6. Discussion

6.1. Theoretical implications

Our research contributes to the *innovation management literature*. Owing to the lack of a conceptually and empirically validated understanding of the interaction of exploitation and exploration on radical and incremental innovation performance respectively, we contribute to developing theory that more fully explains this interaction and its effects. Scholars unitarily agree that both, exploitation and exploration are needed to innovate (Raisch & Birkinshaw, 2008) and have researched the interaction effects of both learning types. Their results reveal positive effects on firms' innovation performance (see Table 2) (He & Wong, 2004; Katila & Ahuja, 2002; Nerkar, 2003; Russo & Vurro, 2010). Our study complements this literature. We provide a finer grained understanding of innovation performance effects by distinguishing between incremental and radical innovation performance while testing for linear *and* non-linear relationships. With our study, we advance theorizing and add evidence to the debate that the interrelationship of exploitation and exploration is beneficial beyond the beneficial effects of exploitation and exploration separately (Andriopoulos & Lewis, 2009; Colbert, 2004; Gibson & Birkinshaw, 2004; He & Wong, 2004; Petersen, et al., 2004). In particular, we disentangle the effects of interaction from a positive one on innovation performance in general (Katila & Ahuja, 2002) to one that is beneficial for incremental (H1) but not for radical (H2) innovation performance. Finding support for Hypothesis 1 reflects the argument that continuous incremental innovation performance is hard to attain if new knowledge is not explored (Corso & Pellegrini, 2007). When coupled with a medium level of exploring new knowledge, the exploitation of existing knowledge enhances incremental innovation performance (see Figure 3b). However, we do not find support for Hypothesis 2. This indicates that the mechanisms of exploitation which assist the increase in absorptive capacity and, thus, can enhance organizations to fruitfully evaluate and integrate distant knowledge is not effective. Organizations may not appreciate distant knowledge (as elicited by exploration) against the background of extant knowledge (as entailed in a firm's absorptive capacity and enhanced by exploitation) and, hence, fail to integrate and transform it into radically new products (Criscuolo, Dahlander, Grohsjean, & Salter, 2017).

Moreover, our study contributes to the theory of *organizational learning*, which emphasizes that both exploitation and exploration are equally important for a firm's long-term growth and survival and also for innovation performance and that maintaining an appropriate balance of the two is crucial (March, 1991; Raisch, Birkinshaw, Probst, & Tushman, 2009; Uotila, Maula, Keil, & Zahra, 2009). Studies have conceptualized balance as symmetrical presence and magnitude of exploitation and exploration (He & Wong, 2004; Katila & Ahuja, 2002) with the caveat that a system with little emphasis on each activity will not exert superior performance effects (Cao, et al., 2009).

In particular, studies have implied and tested that *high exploitation* needs to be combined with *high exploration* (i.e., a high-high combination) to achieve superior performance with results however ranging from the confirmation of the positive effects of a high-high combination on firm performance (Katila & Ahuja, 2002) to insignificant (He & Wong, 2004) or even negative effects (Atuahene-Gima, 2005). Further, scholars have argued that a *high* (low) exploration can be coupled with *low* (high) exploitation*,* for example, to enhance incremental (radical) innovation performance (Atuahene-Gima & Murray, 2007; Danneels, 2002). While such high-low, low-high combinations are asymmetrical in the sense of an equipoise, the two combination pairs are symmetric in the sense of mirroring.

Our study, however, lends theoretical and empirical support to a relationship that is truly asymmetric and more complex than originally thought. In this respect, our study offers two important contributions. *First*, we find that incremental innovation performance is driven by an interaction between exploitation and exploration. This interaction, however, is asymmetrical. In particular, incremental innovation performance is highest when exploitation interacts with an intermediary level of exploration (rather than with an equally high or opposing low level of exploration). *Second*, we find that radical innovation performance is solely driven by exploration. A coupling of exploration with exploitation and, thus, symmetry in the sense of a reciprocal value-adding relationship between the two learning processes for the benefit of radical innovation performance does not exist. Consequently, our results suggest rejecting the theoretical assumptions of symmetric and 'mechanistic' combinations as being most beneficial for incremental and radical innovation performance. Instead, they propose an asymmetric exploitation-exploration combination and supports theoretical and empirical research taking a more 'organic' stance. Thus, we contribute to a finer grained understanding of how to appropriately balance exploitation and exploration not only for radical and incremental innovation but potentially also for firm performance.

Moreover, the ambidexterity literature has largely followed the notion of structural separation which has advocated a separation of exploitation and exploration for the purpose of obtaining separate outcomes, namely incremental and radical innovation (e.g., Arnold, et al., 2011; Yalcinkaya, et al., 2007). Our findings, however, suggest a partial separation. In particular, they suggest a structural separation of exploration for radical innovation purposes and paradoxical thinking for the integration of exploration with exploitation for incremental innovation. Theoretically, this implies that neither structural ambidexterity nor the paradoxical view of ambidexterity captures the full complexity of managing exploration and exploitation processes for innovation outcomes. Instead, both are needed to secure the long term performance of firms through continuous incremental and radical innovation. Thus, our study also advocates to adopt a multilevel perspective, combining ambidexterity approaches at the organizational level with those at the individual level.

Further, we corroborate and add insights to the main effects of exploitation and exploration on radical and incremental innovation performance. In the course of analyzing the interaction effects of exploitation and exploration on incremental and radical innovation performance, we replicate tests of the main effects between the dependent and independent variables (see Figure 3a). Our findings corroborate past research and extend it. For an overview of past research on these main effects, see Table 1. Unsurprisingly, we find positive effects of exploitation on incremental innovation performance and positive effects of exploration on radical innovation performance (Yalcinkaya, et al., 2007). Further, we do not find an effect of exploitation on radical innovation performance. This is in line with findings of prior studies which show mixed results that range from negative effects to not finding an effect (e.g., Hernandez-Espallardo, et al., 2012). In line with but yet novel to the literature, we find an inverse U-shaped effect of exploration on incremental innovation performance with an emphasis on the rising part of the curve.

Recently, scholars have started to study dynamic ambidexterity examining firms' capabilities to adapt their exploitation-exploration balance over time and according to environmental changes (Luger, et al., 2018). Taking a static stance, our study provides a potential starting point for studies under the dynamic perspective. It elicits an effective exploitation-exploration balance at a given point in time and under circumstances of relative resource abundance and economic growth. It remains to be studied how this effective balance will need to change over time with a changing economic situation.

6.2. Managerial implications

Our research results inform managers how to facilitate their firm's innovativeness most efficiently by eliciting how exploitation, exploration, and their interaction lead to incremental innovation performance, and that solely exploration leads to radical innovation. Subsequently, we make two suggestions on how firms can make those mechanisms work.

First, managers could establish two units that mostly operate separately, i.e., nearly isolated subgroups (Ettlie, et al., 1984; Fang, et al., 2010; Tushman & O'Reilly III, 1996). One unit would focus on exploration to attain radical innovation performance and one unit would pursue both learning activities, simultaneously performing exploitation and an intermediate degree of exploration, aimed at incremental innovation performance. The radical innovation unit would be much like a *skunkworks* unit in established firms (De Burcharth & Ulhøi, 2011). This is consistent with the literature that proposes that one isolates groups and gives them considerable autonomy, so they can work on new products or services that differ radically from the organization's existing ones. Alternatively, large and medium-sized firms increasingly invest corporate venture capital in R&D-activities of start-ups in order to benefit from exploring new trends and technologies of these external units. While the approach to implement two separate units is in line with the literature (Lubatkin, et al., 2006), it requires sufficient resources and capabilities. It may lead to an increase in complexity for the management with regard to different organizational structures, cultures, leadership styles, and strategies. For small firms in particular, this is challenging due to restricted resources for implementing a separate unit for exploring new trends and new-to-the-world technologies (e.g., Mashahadi, Ahmad, & Mohamad, 2016). In recent years, some firms overcome this restriction by establishing a spin-off by means of extern venture capital.

However, in the incremental innovation unit (Gibson & Birkinshaw, 2004; Simsek, Heavey, Veiga, & Souder, 2009) managers need to provide for the joint pursuit of exploitation and exploration, and, thus, manage the tensions between exploitation and exploration within the unit. To manage these tensions studies suggest that management helps individuals develop the behavioral capacity to allocate their time between the two types of activities, to balance planned and emergent activities, to reconcile market and technological understandings or to give employees more space of freedom within their daily routines to experiment and explore. Social negotiating and sanctioning ideas play an important role in these activities (Lassen, Waehrens, & Boer, 2009; Papachroni, et al., 2015; Stokes, et al., 2015). Second, managers could establish two units that interact (i.e., mainly at a macro-level), thereby implementing partitional ambidexterity (Simsek, et al., 2009). Whereas one unit focuses on exploration for radical innovation performance, the other unit focuses on exploitation, receiving some intermediate explorative input from the first unit for knowledge integration (Grant, 1996) or the purpose of incremental innovation performance. Therefore, managers need to ensure intermediate-level knowledge transfer from the radical innovation group to the incremental innovation group (Szulanski, 2000). According to our results, either high or low knowledge transfer levels would be associated with lower levels of incremental innovation performance. This is in line with the literature's organizational learning arguments which suggest that dividing an organization into subgroups with some barriers to diffusion between them can help the organization achieve a balance between exploitation and exploration (March, 2005) and its findings that a moderate cross-group linking between semi-isolated subgroups is most beneficial for a balance between exploitation and exploration (Fang, et al., 2010). Behavioral integration efforts, such as information exchange and joint decision making of top management team may foster such linkages (Carmeli & Halevi, 2009;

Lubatkin, et al., 2006). Although integration efforts also imply that exploitative results are transferred to the radical innovation unit, this should not be harmful. As our study shows, exploitation has no detrimental effect on radical innovation performance.

Overall, organizations can exhibit different forms of ambidexterity, as both options comprise elements of differentiation and integration. This supports arguments by Andriopoulos et al. (2009), who argue that integration and differentiation offer powerful complementarity tactics for fostering ambidexterity, whereas "ambidexterity researchers have typically focused on one side or the other of this duality" (Raisch, et al., 2009, p. 686). While in our first option, managers would mainly manage the tensions between the two learning activities as well as the integration of the close and distant knowledge acquired at the unit level (i.e., within one unit), in option two, managers would manage the tensions at the company level (i.e., between units) and manage the knowledge integration at the unit level.

Finally, management scholars seldom hold that any one organization structure is universally beneficial; similarly, these two options are probably not equally effective across company sizes and contexts. Contingency theory has argued that the optimal structure depends on a number of other factors (Donaldson, 2001). What exactly these factors are could be subject to further research.

6.3. Limitations and future research directions

Our study has limitations. It was conducted in Switzerland, a well-developed and highly innovative country (Kelley, et al., 2016; Worldbank, 2016). However, relating our study's results to the extant literature, we find indicators that suggest that the developmental status of a country may be influential on the effects that exploitation and exploration have on innovation performance. (For more detail, see Table 1 and Table 2 that contain study results from developed and developing countries.) Thus, the results are not generalizable to developing countries. Future research should enhance our understanding of the particular effect differences of exploitation and exploration in developed and in developing countries and elaborate on the theoretical underpinnings that explain these differences.

While our study has researched the blend of exploitation and exploration and has built on the notion of structural ambidexterity, future research can help to enhance our understanding of ambidexterity by conducting studies under a more comprehensive view by considering the innovation performance of firms that pursue both, the structural and the paradoxical approach.

In addition, future studies could also expand this research by investigating the balance of exploration and exploitation for service or process innovation performance as well as contingent on the environment. In the course of increasing digitization, business models and business model innovation will become more and more important (Massa & Tucci, 2013). Hence, researching exploitation, exploration, and their interaction effects on business model innovation performance will be an important path of further research. Further, our study has not considered environmental conditions for the appropriate balance of exploitation and exploration. Future studies could do so and extend e.g., the study by (Uotila, et al., 2009) who took industry technological dynamism into consideration. Finally, we collected our data by questionnaires mailed to CEOs and senior executives. Future research could consider responses from innovation and technology departments, for example, R&D managers.

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Appendix

Table 1: *Studies on exploitation, exploration, and their direct effects on incremental and radical innovation performance*

		Effect of exploitation on …		Effect of exploration on …		Interaction effect of exploitation and exploration on …	
Study	**Data origin**	**incremental innovation**	**radical innovation**	**incremental innovation**	**radical innovation**	**incremental innovation**	**radical innovation**
Atuahene-Gima (2005)	China[3]	hypo: positive result: positive	hypo: negative result: negative	hypo: negative result: negative	hypo: positive result: positive	hypo: interaction, non-directional result: no effect	hypo: interaction, no-directional result: negative high-high interaction; high exploration and low exploitation are beneficial
Yalcinkaya et al. (2007) [1]	US	hypo: positive result: positive	hypo: negative result: negative	hypo: positive result: positive	hypo: positive result: positive	-	-
Hernandez-Espallardo et al. (2011) intra-organizational	Spain	hypo: positive result: positive	hypo: positive result: negative	hypo: none result: no effect	hypo: none result: no effect	-	-
Hernandez-Espallardo et al. (2011) inter-organizational	Spain	hypo: none result: no effect	hypo: none result: no effect	hypo: positive result: positive	hypo: positive and stronger than for incremental result: positive and stronger than for incremental	-	-
Arnold et al. (2011)	US	hypo: positive result: positive	hypo: negative result: negative	hypo: negative result: no effect	hypo: positive result: positive	-	-
Corso & Pellegrini (2007)	-[2]	positive	positive	positive	positive	positive	-

[1] novelty of product or innovation measured as a continuum

[2] conceptual paper

[3] country classified as developing countries at the time of and prior to the studies' publication (Worldbank 2016)

Table 2: *Studies on exploitation, exploration, and their interaction effects on overall innovation performance*

Study	Data origin	Effect of exploitation on innovation overall	Effect of exploration on innovation overall	Interaction effect of exploitation and exploration on innovation overall
Katila & Ahuja (2002)	Japan, US, Europe	hypo: ∩ result: ∩	hypo: ∩ result: positive	hypo: positive interaction result: positive interaction
Nerkar (2003)	US	hypo: ∩ result: positive	hypo: ∩ result: ∩	hypo: positive interaction result: positive interaction
He & Wong (2004)	Singapore, Malaysia[1]	hypo: - result: positive	hypo: - result: positive	hypo: - result: no effect (result fit as matching: none)
Atuahene-Gima & Murray (2007)	China[3]	hypo: ∩ result: U	hypo: ∩ result: U	hypo: competing positive and negative interaction result: negative interaction; medium-high exploitation and high exploration are detrimental low exploitation and exploration are beneficial
Russo & Vurro (2010)	Japan, US, Europe	hypo: competing positive and negative result: positive	hypo: competing positive and negative result: positive	hypo: positive result: positive (internal exploitation and external exploration)
Li et al. (2010)[2]	Taiwan[3]	hypo: ∩ with low levels being beneficial and high levels being detrimental result: ∩	hypo: ∩ with low levels being beneficial and high levels being detrimental result: ∩	hypo: negative (any high-low interaction) result: negative (any high-low interaction)
Lee et al. (2017)	India[3]	hypo: - result: U	hypo: - result: ∩	hypo: - result: no effect hypo: positive as both increase simultaneously result: no effect hypo: negative as the imbalance between both increases result: no effect Post-hoc analysis: a) negative interaction (any low-low-interaction) b) positive interaction if exploration is sufficiently high c) negative interaction if exploitation is below the median

U: U-shaped

∩: inverse U-shaped

[1] majority of sample from Singapore (developed country)

[2] at project level, ∩ inverse U-shaped, U U-shaped

[3] country classified as developing country at the time of and prior to the studies' publication (Worldbank 2016)

Table 3: *Construct measurement and construct validity assessment*

Construct		Measures	Factor loadings	Average variance extracted	Cronbach's alpha	Factor reliability
Radical innovation performance[ab]	1.	% of total sales from highly innovative new products* introduced by your firm in the last three years[1]	0.57 (8.56)	0.51	0.76	0.76
	2.	Compared to your major competitor, your firm introduced more highly innovative products* in the last three years[2]	0.84 (15.18)			
	3.	Your firm frequently introduced highly innovative new products* into markets totally new to the firm in the last three years[2]	0.72 (10.74)			
		*remark in the questionnaire: new-to-the-world products and/or product lines that are new to the firm and market				
Incremental innovation performance[ab]	1.	% of total sales from moderately innovative new products** introduced by your firm in the last three years[1]	0.42 (5.76)	0.45	0.67	0.70
	2.	Compared to your major competitor, your firm introduced more moderately innovative products** in the last three years[2]	0.92 (12.69)			
	3.	Your firm frequently introduced moderately innovative new products** into markets totally new to the firm in the last three years[2]	0.61 (7.29)			
		**remark in the questionnaire: lines new to a firm but not new to the world, new products to the existing product line, and/or product relaunches				
Exploration[b]		Over the last three years, to what extent has your firm…[3]		0.51	0.83	0.80
	1.	.. generated knowledge for completely new products and technologies?	0.73 (13.78)			
	2.	...searched for ideas with no identifiable market needs?	0.66 (10.47)			
	3.	...searched for new products or technologies involving experimentation and high risk?	0.72 (11.54)			
	4.	...strengthened knowledge in areas in which it had no prior experience?	0.74 (12.31)			
	5.	...generated knowledge about a new product that took the firm beyond its current market-product experiences?	0.76 (12.92)			
Exploitation[b]		Over the last three years, to what extent has your firm…[3]		0.45	0.78	0.80
	1.	...invested in enhancing skills in exploiting mature technologies that improve productivity?	0.59 (9.25)			
	2.	..strengthened your knowledge for projects that improve efficiency of existing innovation activities?	0.68 (9.25)			
	3.	...upgraded current knowledge for familiar products and technologies?	0.73 (8.85)			
	4.	...searched for solutions to customer problems that are near to existing solutions rather than completely new solutions?	0.78 (10.34)			
	5.	...strengthened your knowledge for products and technologies in which the firm already possesses significant experience?	0.56 (6.76)			

[a]Source: Chandy and Tellis, 1998
[b]Source: Atuahene-Gima, 2005
[c]Source: Miracle, 1965; Hart, 1989
[d]Source: Jaworski and Kohli, 1993
[e]Source: Benner and Tushman, 2002; Luzon and Pasola, 2011

[1]Scale format: 1='less than 5%', 2='5%-10%', 3='11%-15%', 4='16%-20%', 5='>20%'
[2]Scale format: 1='strongly disagree'; 5='strongly agree'
[3]Scale format: 1='Very small', 5='Very large'
[4]Scale format: 1='Strong competitors' advantage', 5='Our strong advantage'

Table 3 (Continued): *Construct measurement and construct validity assessment*

Construct		Measures	Factor loadings	Average variance extracted	Cronbach's alpha	Factor reliability
Control variables:						
Firm size		What is the approximate number of employees in your company in Switzerland? (1='20-99', 2='100-499', 3='more than 499')				
Sector[c]		Which of the following best describes the main industry your company operates in? (1='Consumer Durables?, 2='Fast Moving Consumer Goods (FMCG)', 3='Materials and Components', 4='Capital Industrial Equipment')				
Demand complexity[d]		Customers are increasingly demanding better quality and reliability in the products and services they buy.[2]				
Technological uncertainty[d]		Technological change in this industry is rapid.[2]				
Competitiveness[d]		Competition is well established and entrenched.[2] (r)				
Process efficiency[e]	1.	Cost advantage in production.[4]	0.63 (3.60)	0.28	0.52	0.53
	2.	Our purchasing is cost efficient.[2]	0.74 (4.21)			
	3.	Our overhead/administration is cost efficient.[2]	0.78 (4.16)			
Time-to-market[e]		Ability to implement a product concept quickly.[4]				
Superior customer service[e]		Superior levels of customer service and support.[4]				
Product development alliances[b]	1.	Shared technology through strategic alliances or partnerships.[4]	0.63 (5.21)	0.52	0.75	0.75
	2.	Cooperation with external partners in generating product ideas.[4]	0.74 (9.67)			
	3.	Cooperation with external partners in product development.[4]	0.78 (8.73)			
Market launch capability[b]		Ability to launch successful new products.[4]				

[a]Source: Chandy and Tellis, 1998

[b]Source: Atuahene-Gima, 2005

[c]Source: Miracle, 1965; Hart, 1989

[d]Source: Jaworski and Kohli, 1993

[e]Source: Benner and Tushman, 2002; Luzon and Pasola, 2011

[1]Scale format: 1='less than 5%', 2='5%-10%', 3='11%-15%', 4='16%-20%', 5='>20%'

[2]Scale format: 1='strongly disagree'; 5='strongly agree'

[3]Scale format: 1='Very small', 5='Very large'

[4]Scale format: 1='Strong competitors' advantage', 5='Our strong advantage'

Table 4: *Correlation matrix and descriptive statistics of measures*

Variables	Mean	Standard deviation	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
1. Small firm size	0.50	0.50	1																
2. Large firm size	0.13	0.34	0.39***	1															
3. Consumer durables industry	0.25	0.44	-0.02	0.10	1														
4. Fast moving consumer goods industry	0.25	0.44	0.01	-0.02	0.34***	1													
5. Materials and components industry	0.27	0.44	0.06	-0.07	0.35***	0.35***	1												
6. Demand complexity	4.34	0.77	-0.03	0.04	-0.01	-0.01	-0.04	1											
7. Technological uncertainty	3.22	1.07	0.10	-0.03	0.00	0.03	-0.02	0.13	1										
8. Competitiveness (reversed)	2.55	1.05	0.07	-0.03	-0.02	-0.10	0.07	-0.09	-0.09	1									
9. Time-to-market	3.42	0.82	0.03	0.06	-0.01	0.07	0.08	0.05	-0.05	-0.16*	1								
10. Superior customer service	3.71	0.75	-0.04	0.02	0.10	-0.14	0.01	-0.07	0.01	0.03	0.00	1							
11. Process efficiency	2.35	0.45	0.09	0.02	0.01	0.03	0.06	-0.10	0.18*	-0.07	0.26***	-0.03	1						
12. Market launch capability	3.47	0.96	-0.08	0.06	0.09	-0.14	0.01	-0.06	0.03	-0.18*	0.35**	0.13	0.16*	1					
13. Product development alliances	2.53	0.51	-0.05	0.09	0.07	-0.06	-0.08	0.06	0.00	-0.09	-0.05	0.06	0.11	0.24**	1				
14. Exploration	2.31	0.63	-0.14	0.20**	0.01	-0.08	0.11	0.05	0.08	-0.07	0.22**	0.04	0.19*	0.18*	0.24**	1			
15. Exploitation	2.58	0.44	-0.08	0.12	0.06	-0.13	-0.03	0.05	0.13	-0.08	0.08	0.07	0.19*	0.12	0.20**	0.19*	1		
16. Radical innovation performance	2.04	0.81	-0.03	0.04	0.02	-0.16*	0.04	0.18*	0.16*	-0.19*	0.17*	0.05	0.10	0.43***	0.23**	0.47**	0.24**	1	
17. Incremental innovation performance	2.41	0.65	-0.14	0.14	0.06	-0.07	-0.07	-0.02	0.20**	-0.12	0.10	0.17*	-0.01	0.32***	0.14	0.24**	0.27**	0.38***	1

*p<0.05, **p<0.01, ***p<0.001 (two-tailed)

Table 5: *Regression analyses: Standardized results for incremental innovation performance*

Dependent variable	Incremental innovation performance											
	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Controls												
Small firm size	-0.10	(-1.20)	-0.08	(-1.06)	-0.07	(-0.86)	-0.04	(-0.55)	-0.04	(-0.55)	-0.03	(-0.40)
Large firm size	0.08	(1.05)	0.07	(0.88)	0.05	(0.62)	0.05	(0.71)	0.05	(0.70)	0.04	(0.56)
Industry 1: Consumer durables	-0.04	(-0.44)	-0.03	(-0.31)	-0.03	(-0.35)	-0.01	(-0.18)	-0.01	(-0.18)	-0.02	(-0.20)
Industry 2: Fast moving consumer goods	-0.07	(-0.73)	-0.03	(-0.34)	-0.03	(-0.31)	-0.06	(-0.69)	-0.06	(-0.69)	-0.05	(-0.57)
Industry 3: Materials and components	-0.08	(-0.92)	-0.06	(-0.70)	-0.08	(-0.94)	-0.08	(-0.99)	-0.08	(-0.98)	-0.10	(-1.17)
Demand complexity	-0.06	(-0.82)	-0.07	(-0.91)	-0.07	(-0.99)	-0.07	(-0.97)	-0.07	(-0.97)	-0.09	(-1.30)
Technological uncertainty	0.23 **	(3.05)	0.21 **	(2.79)	0.20 **	(2.66)	0.21 **	(3.02)	0.21 **	(3.00)	0.22 **	(3.11)
Competitiveness (reversed)	-0.05	(-0.64)	-0.04	(-0.54)	-0.04	(-0.54)	-0.03	(-0.47)	-0.03	(-0.46)	-0.02	(-0.34)
Time-to-market	0.06	(0.71)	0.04	(0.55)	0.02	(0.21)	0.04	(0.53)	0.04	(0.52)	0.04	(0.47)
Superior customer service	0.11	(1.56)	0.10	(1.45)	0.10	(1.42)	0.10	(1.44)	0.10	(1.43)	0.12	(1.78)
Process efficiency	-0.11	(-1.37)	-0.14	(-1.78)	-0.15 *	(-1.99)	-0.19 *	(-2.58)	-0.19 *	(-2.56)	-0.20 **	(-2.73)
Market launch capability	0.25 **	(3.01)	0.25 **	(3.08)	0.25 **	(3.07)	0.26 **	(3.34)	0.26 **	(3.32)	0.26 ***	(3.46)
Product development alliances	0.07	(0.92)	0.04	(0.52)	0.01	(0.08)	0.04	(0.54)	0.04	(0.54)	0.05	(0.61)
Independent variables												
Exploitation			0.20 **	(2.67)	0.19 *	(2.53)	0.20 **	(2.77)	0.20 **	(2.74)	0.33 ***	(3.42)
Exploration					0.16 *	(2.08)	0.13	(1.69)	0.12	(1.68)	0.15 *	(2.04)
Exploration^2							-0.27 ***	(-3.93)	-0.27 ***	(-3.85)	-0.26 ***	(-3.75)
Exploitation* Exploration									0.00	(0.00)	-0.04	(-0.53)
Exploitation* Exploration^2											-0.20 *	(-2.04)
R-square	0.20		0.24		0.26		0.32		0.32		0.34	
Adjusted R-square	0.13		0.17		0.18		0.25		0.25		0.26	
Change-in-R-Square	0.20		0.04		0.02		0.07		0.00		0.02	
F-Value	3.02 ***		3.43 ***		3.55 ***		4.61 ***		4.31 ***		4.38 ***	
Change-in-F	3.02 ***		7.12 **		4.31 *		15.43 ***		0.00		4.16 *	

*p<0.05, **p<0.01, ***p<0.001 (two-tailed)

Table 6: *Regression analyses: Standardized results for radical innovation performance*

Dependent variable	Radical innovation performance											
	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Controls												
Small firm size	0.01	(0.12)	0.05	(0.77)	0.06	(0.86)	0.06	(0.92)	0.07	(0.98)	0.07	(0.98)
Large firm size	0.01	(0.12)	-0.05	(-0.69)	-0.05	(-0.79)	-0.05	(-0.81)	-0.06	(-0.88)	-0.06	(-0.88)
Industry 1: Consumer durables	-0.08	(-0.99)	-0.09	(-1.18)	-0.08	(-1.10)	-0.09	(-1.17)	-0.11	(-1.35)	-0.11	(-1.35)
Industry 2: Fast moving consumer goods	-0.16	(-1.82)	-0.15	(-1.87)	-0.13	(-1.62)	-0.13	(-1.68)	-0.14	(-1.72)	-0.14	(-1.69)
Industry 3: Materials and components	-0.03	(-0.34)	-0.08	(-1.05)	-0.07	(-0.90)	-0.08	(-0.98)	-0.09	(-1.10)	-0.09	(-1.09)
Demand complexity	0.16 *	(2.29)	0.15 *	(2.34)	0.15 *	(2.31)	0.14 *	(2.24)	0.14 *	(2.28)	0.14 *	(2.26)
Technological uncertainty	0.12	(1.72)	0.09	(1.41)	0.08	(1.24)	0.08	(1.27)	0.07	(1.14)	0.07	(1.13)
Competitiveness (reversed)	-0.10	(-1.36)	-0.09	(-1.50)	-0.09	(-1.44)	-0.09	(-1.49)	-0.11	(-1.66)	-0.11	(-1.65)
Time-to-market	0.05	(0.57)	-0.03	(-0.43)	-0.04	(-0.52)	-0.03	(-0.44)	-0.03	(-0.44)	-0.03	(-0.44)
Superior customer service	0.00	(-0.07)	-0.01	(-0.22)	-0.02	(-0.30)	-0.02	(-0.28)	-0.01	(-0.18)	-0.01	(-0.18)
Process efficiency	0.01	(0.15)	-0.04	(-0.55)	-0.05	(-0.77)	-0.05	(-0.78)	-0.04	(-0.65)	-0.04	(-0.65)
Market launch capability	0.36 ***	(4.55)	0.35 ***	(4.93)	0.35 ***	(4.96)	0.36 ***	(5.02)	0.35 ***	(4.98)	0.35 ***	(4.94)
Product development alliances	0.12	(1.62)	0.02	(0.37)	0.01	(0.16)	0.01	(0.22)	0.02	(0.35)	0.02	(0.35)
Independent variables												
Exploration			0.42 ***	(6.30)	0.42 ***	(6.19)	0.41 ***	(6.12)	0.41 ***	(6.02)	0.41 ***	(4.39)
Exploitation					0.10	(1.61)	0.08	(1.08)	0.08	(1.10)	0.08	(1.07)
Exploitation^2							-0.06	(-0.82)	-0.07	(-1.05)	-0.08	(-1.04)
Exploration* Exploitation									0.08	(1.18)	0.08	(1.10)
Exploration* Exploitation^2											0.00	(0.00)
R-square	0.28		0.42		0.43		0.44		0.44		0.44	
Adjusted R-square	0.22		0.37		0.38		0.38		0.38		0.37	
Change-in-R-Square	0.28		0.15		0.01		0.00		0.01		0.00	
F-Value	4.61 ***		8.17 ***		7.88 ***		7.41 ***		7.08 ***		6.64 ***	
Change-in-F	4.61 ***		39.68 ***		2.60		0.68		1.40		0.00	

*p<0.05, **p<0.01, ***p<0.001 (two-tailed)

Figure 1: *Extant literature on the effects of exploitation and exploration on innovation performance*

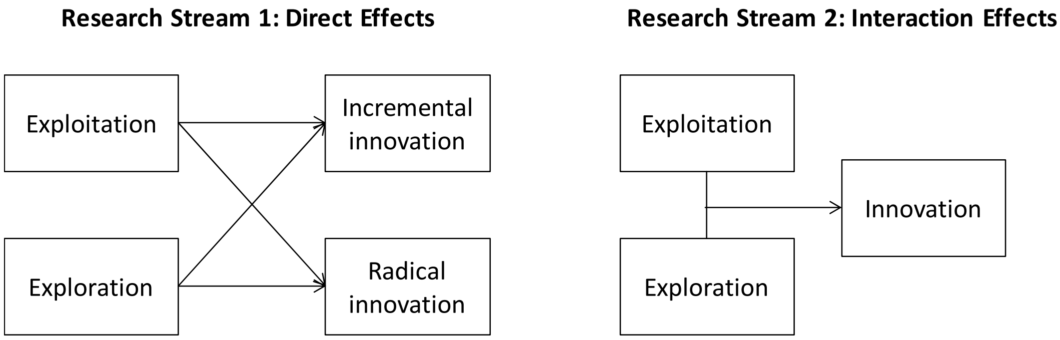


Figure 2: *Overview of hypotheses*

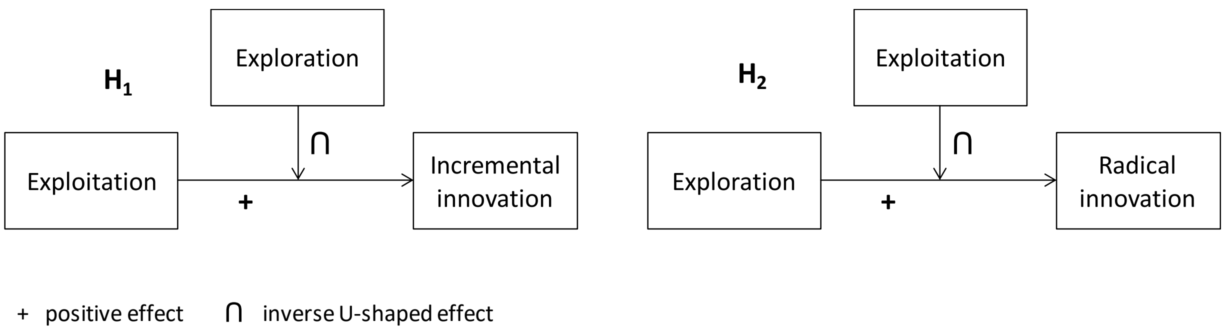
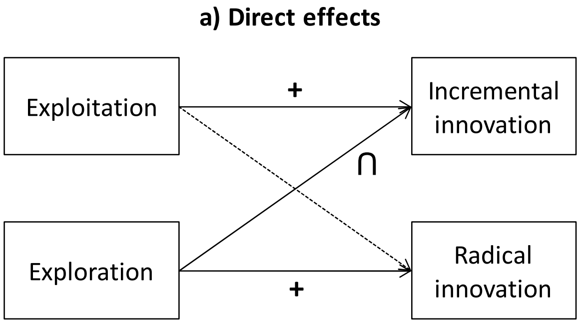


Figure 3: *Overview of results*



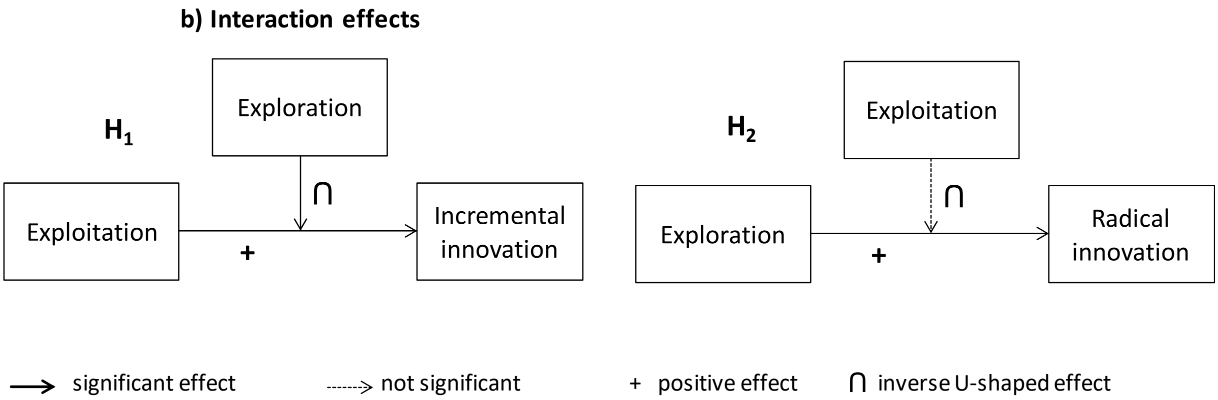


Figure 4: *Moderating effect of exploration*

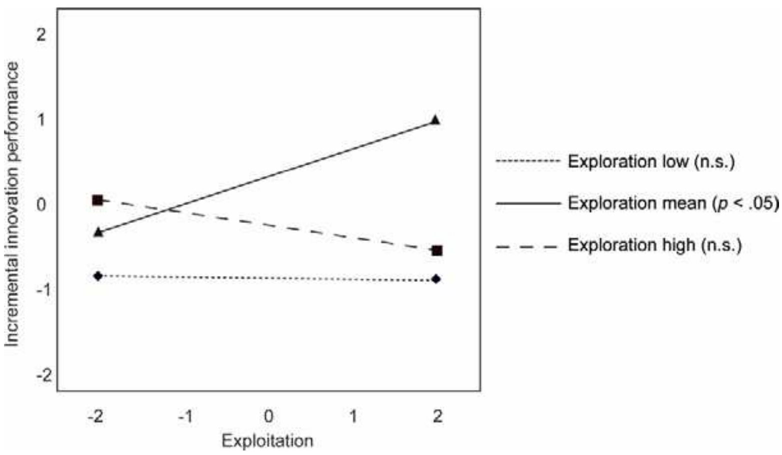


Figure 5: *Inverse U-shaped moderator effect of exploration*